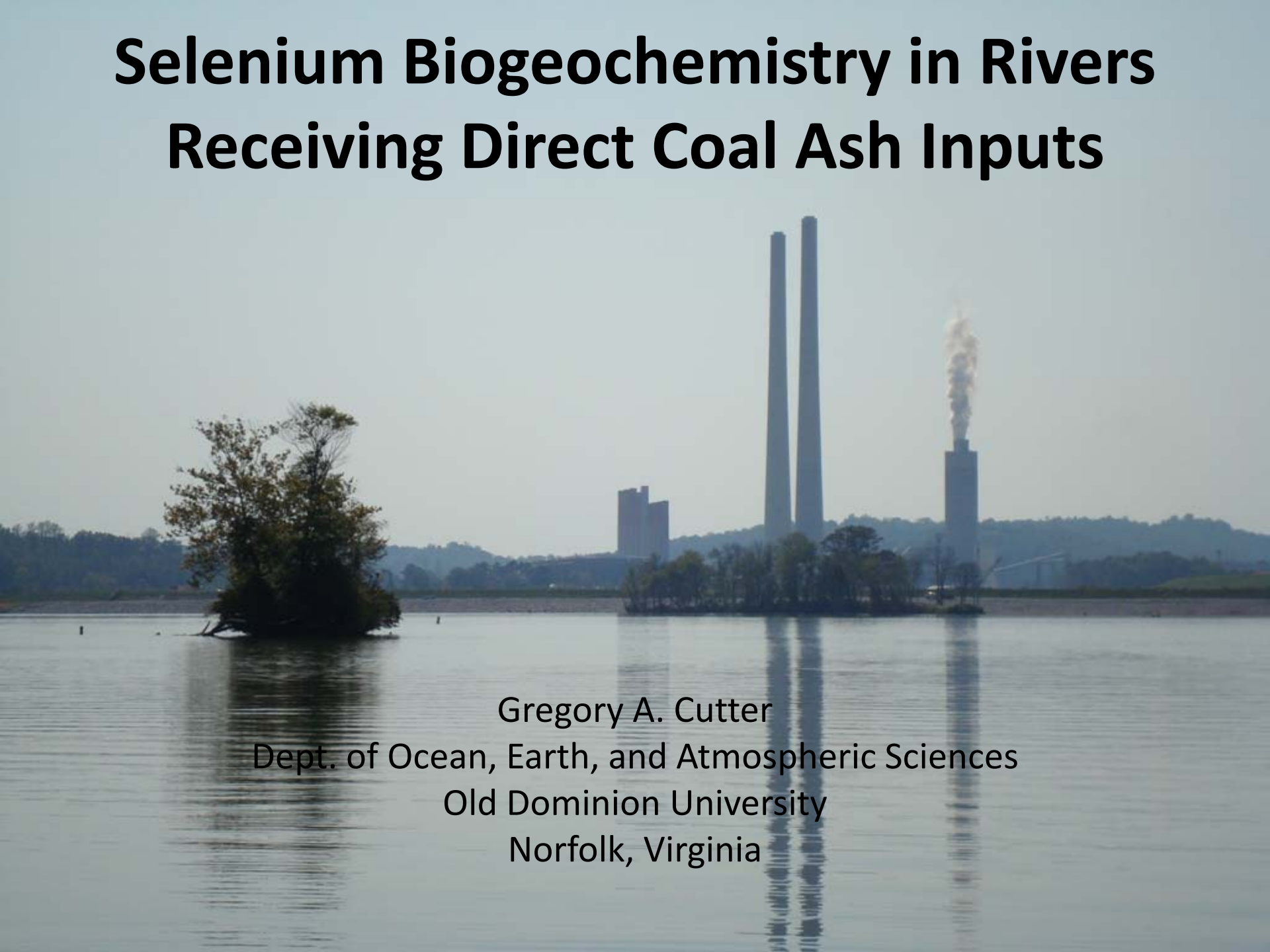
Selenium Biogeochemistry in Rivers Receiving Direct Coal Ash Inputs



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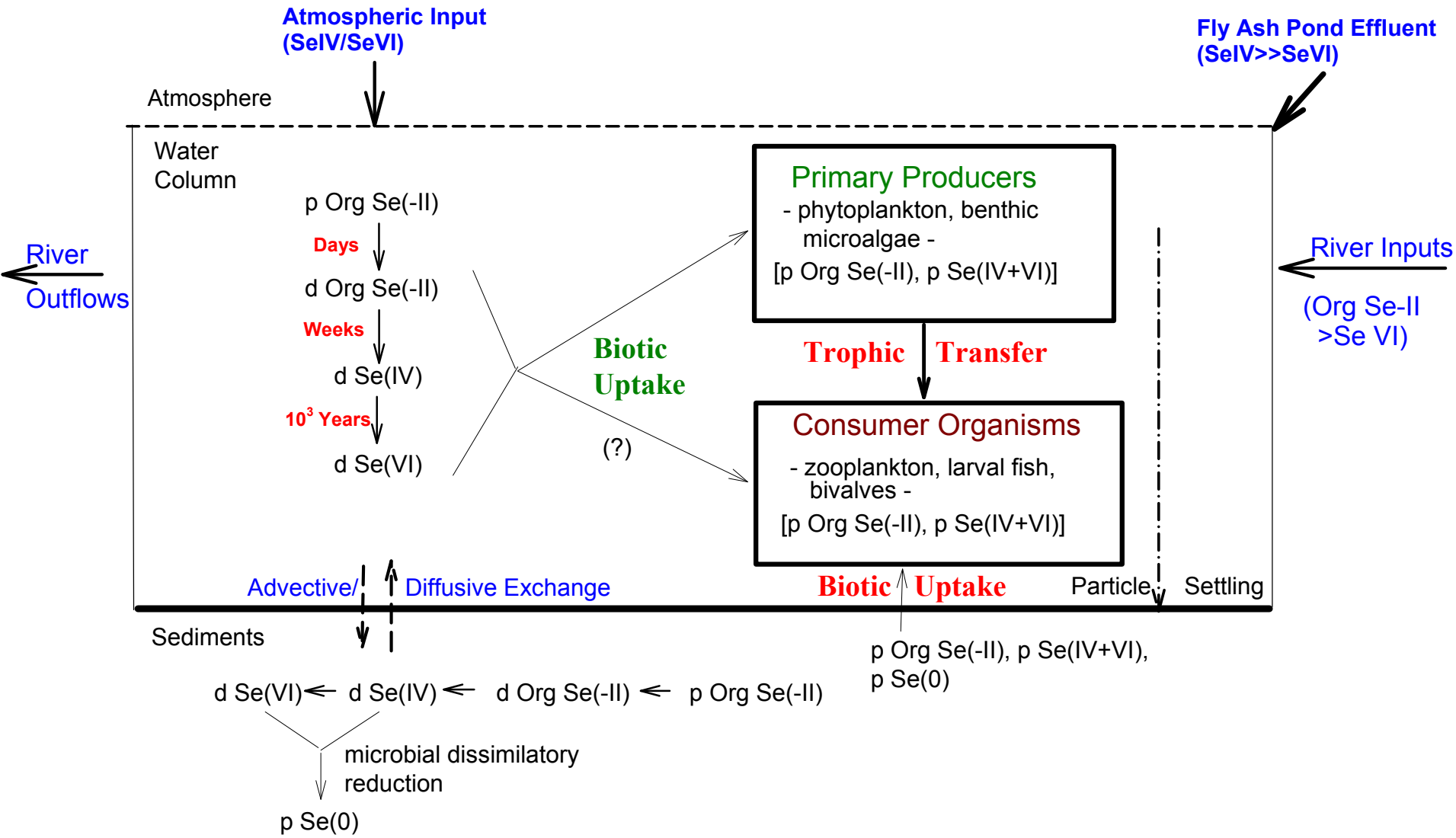
Selenium Speciation

Oxid. State	Chemical Form(s)	*Name*
	Dissolved	
Se(IV)	$SeO_3^{2-} + HSeO_3^-$	*Selenite*
Se(VI)	SeO_4^{2-}	*Selenate*
Se(-II)	Se-amino acids in soluble peptides	*Diss. organic selenide*
Se(0)	Colloidal elemental Se - not truly dissolved	
	Particulate	
Se(IV)	Adsorbed SeO_3^{2-}	
Se(VI)	Adsorbed SeO_4^{2-}, organic selenate esters	
Se(0)	Se(0) precipitates	*Elemental Se*
Se(-II)	Se-amino acids in POM, Rare selenide minerals (e.g., ferroselite, $FeSe_2$) or in pyrite (FeSSe)	*Part. organic selenide*

Selenium Biogeochemistry in Power Plant Cooling Reservoirs



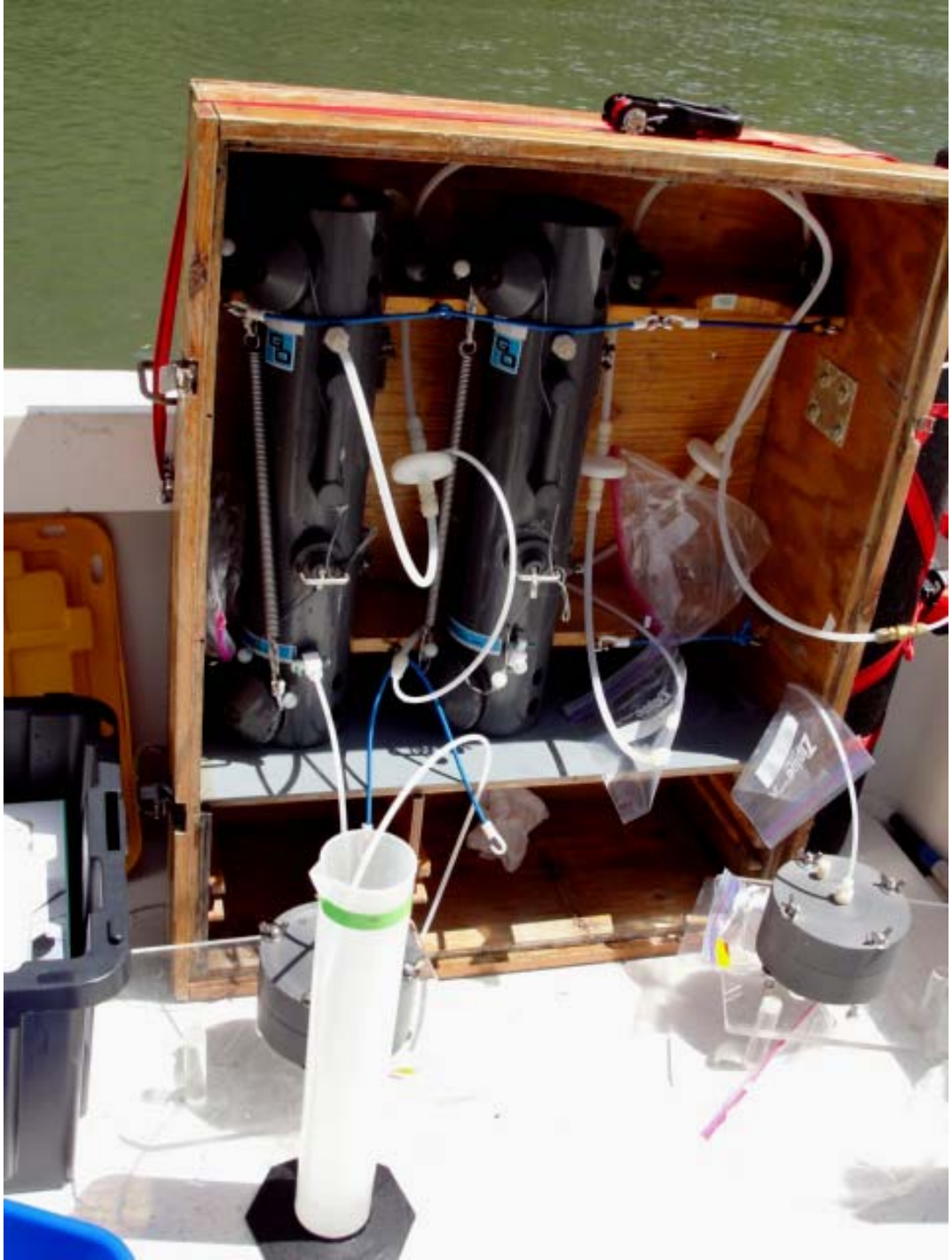
Research Objectives and Approach

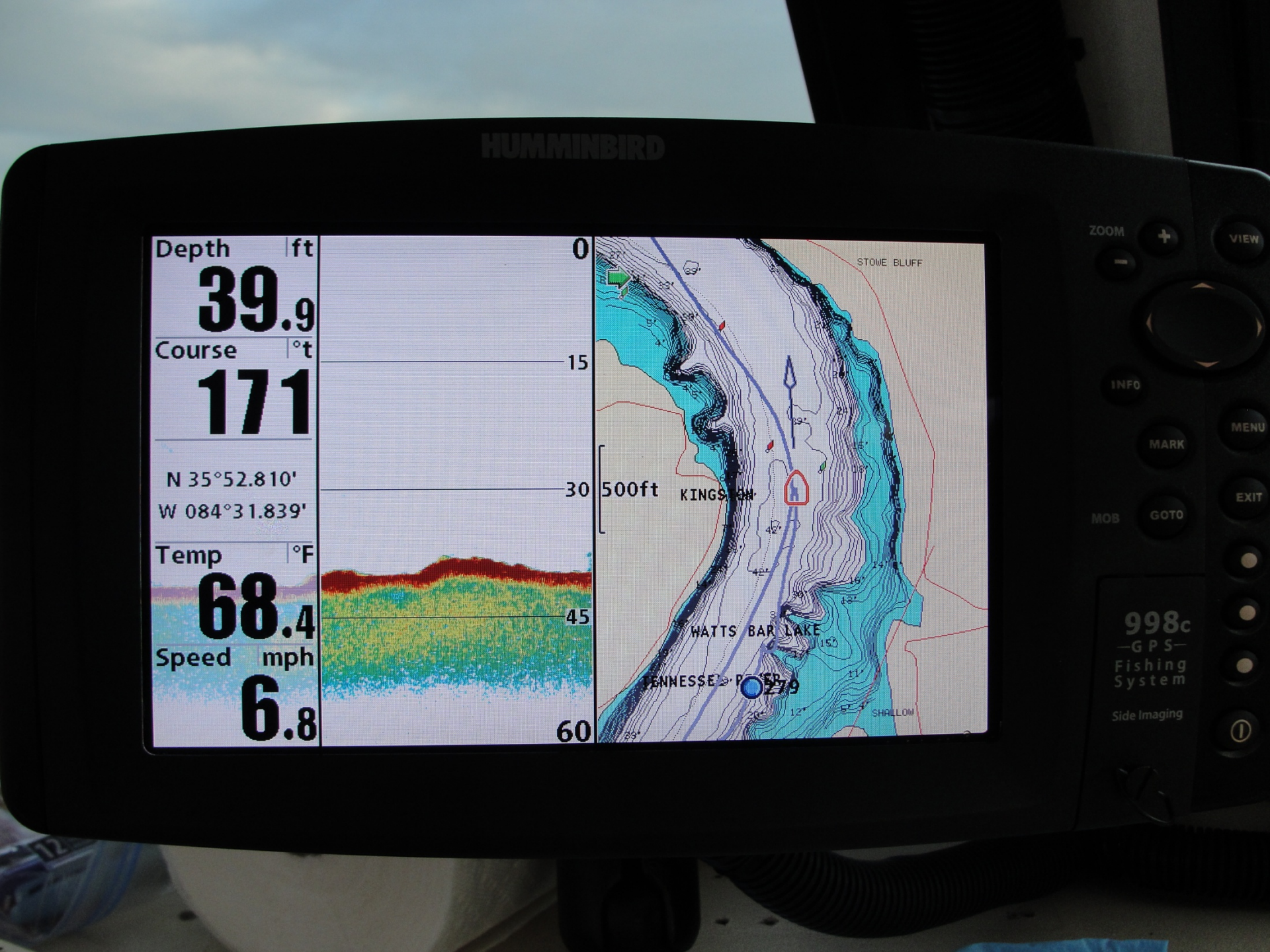
Overall Objective: Qualitatively describe the processes affecting selenium cycling and quantitatively determine the rates of processes for this cycle in a freshwater aquatic system that has received selenium inputs via direct coal ash deposition.

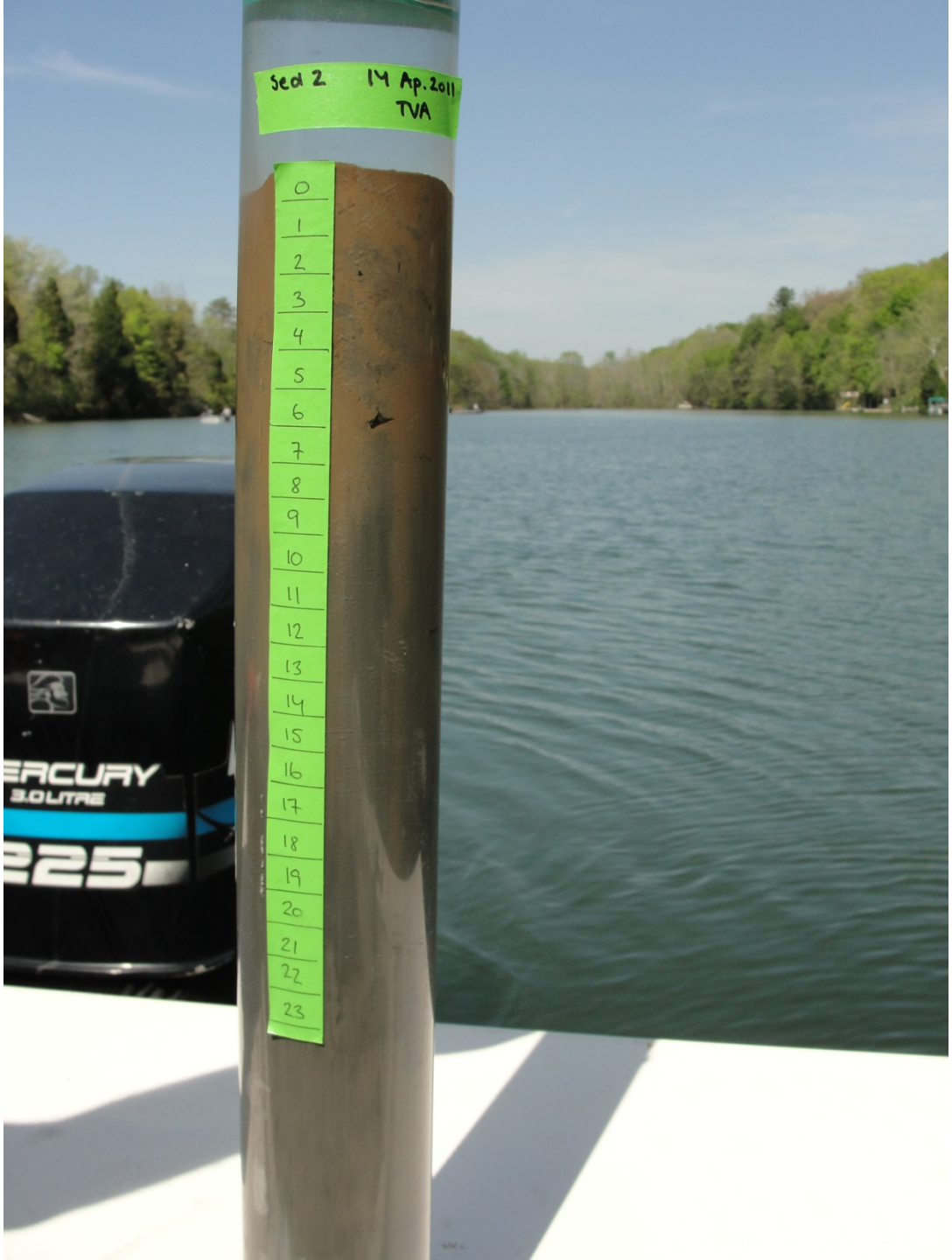
1. What is the speciation of dissolved and particulate selenium in this aquatic system and can it be used to trace ash input?
2. Is the biogeochemical cycle of selenium in a lotic (riverine) system fundamentally different than that in lentic waters ?
3. What are the rates of processes in selenium's biogeochemical cycle (e.g., regeneration of particulate organic selenide to dissolved organic selenide) and are they functions of environmental variables such as temperature and oxygen concentrations?

Approach: Combined field sampling (seasonal, multiple locations, sediments, water column, dissolved and particulate) and laboratory experiments (incubations)

Ocean, Earth & Atmospheric Sciences




HUMMINBIRD
Depth ft
39.9
Course °t
171
N 35°52.810'
W 084°31.839'
Temp °F
68.4
Speed mph
6.8
0
15
30
45
60
500ft
STOWE BLUFF
KINGSTON
WATTS BAR LAKE
TENNESSEE
SHALLOW
ZOOM
VIEW
INFO
MENU
MARK
EXIT
MOB
GOTO
998c
GPS
Fishing System
Side Imaging


Sed 2
14 Ap. 2011
TVA
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
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18
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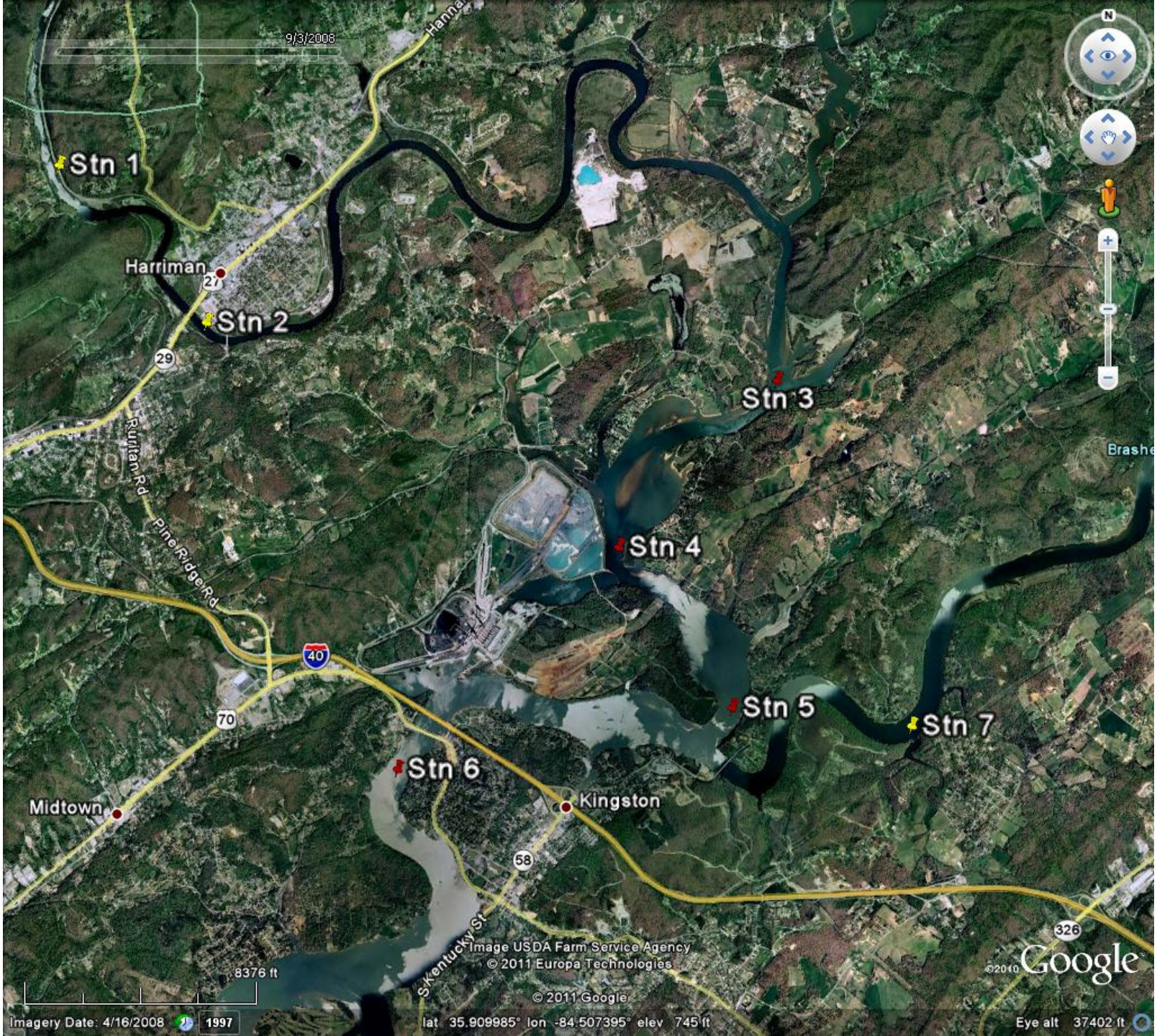
22
23
ERCURY
3.0 ULTRA
225

A
Sed Core 5
7/27/2011
LUCISCOTT

Hefty
JUMBO


9/3/2008
Stn 1
Harriman
Stn 2
Stn 3
Stn 4
Stn 5
Stn 6
Stn 7
Kingston
Midtown
Ruritan Rd
Pine Ridge Rd
S Kentucky St
Brashe
8376 ft
Image USDA Farm Service Agency
© 2011 Europa Technologies
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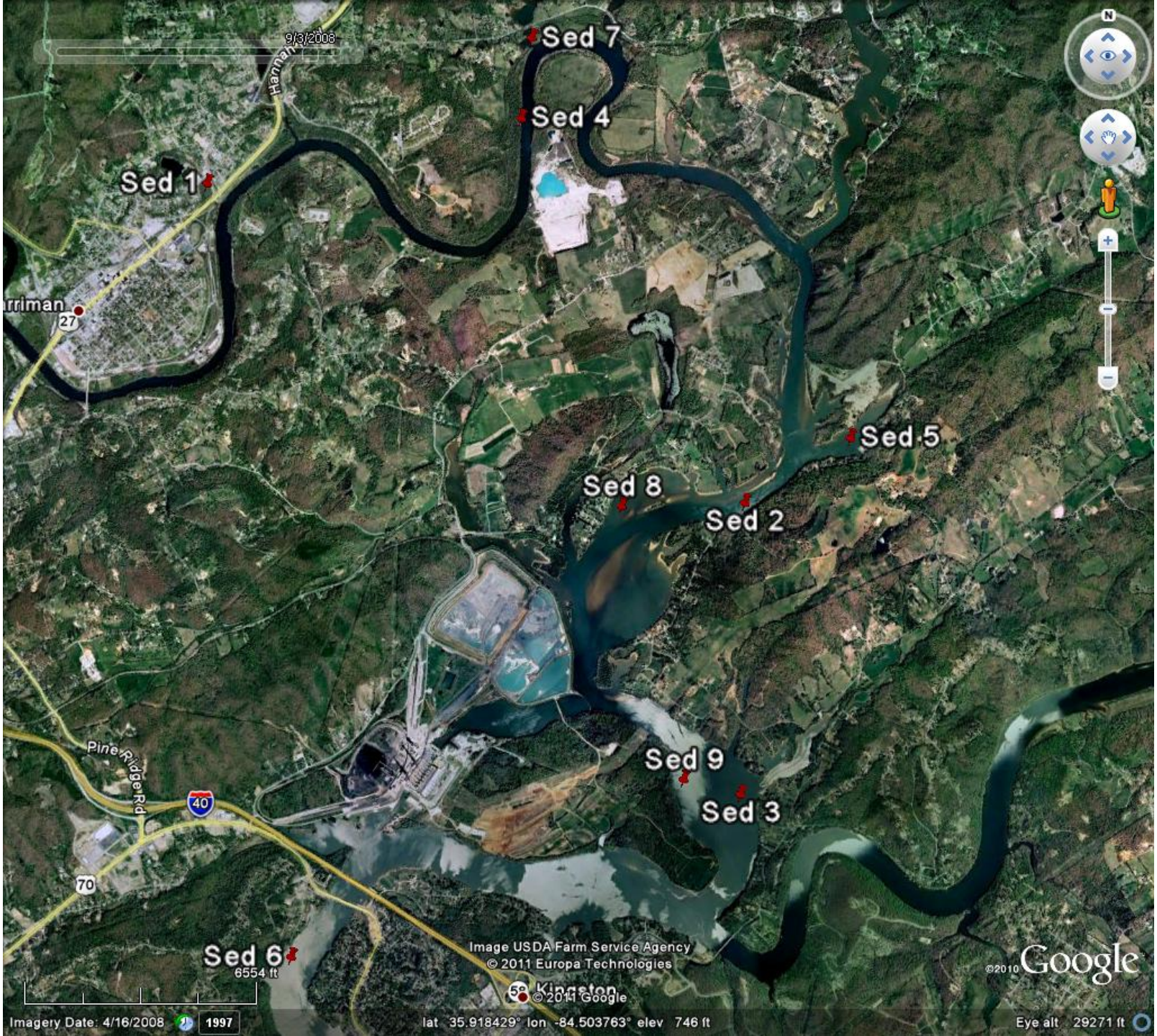
©2010 Google
Imagery Date: 4/16/2008
1997
lat 35.909985° lon -84.507395° elev 745 ft
Eye alt 37402 ft


9/3/2008
Sed 7
Sed 4
Sed 1
Hannah
rriman
27
Sed 5
Sed 8
Sed 2
Pine Ridge Rd
40
Sed 9
Sed 3
70
Sed 6
6554 ft
Image USDA Farm Service Agency
© 2011 Europa Technologies
Kingston
© 2011 Google
©2010 Google
Imagery Date: 4/16/2008
1997
lat 35.918429° lon -84.503763° elev 746 ft
Eye alt 29271 ft

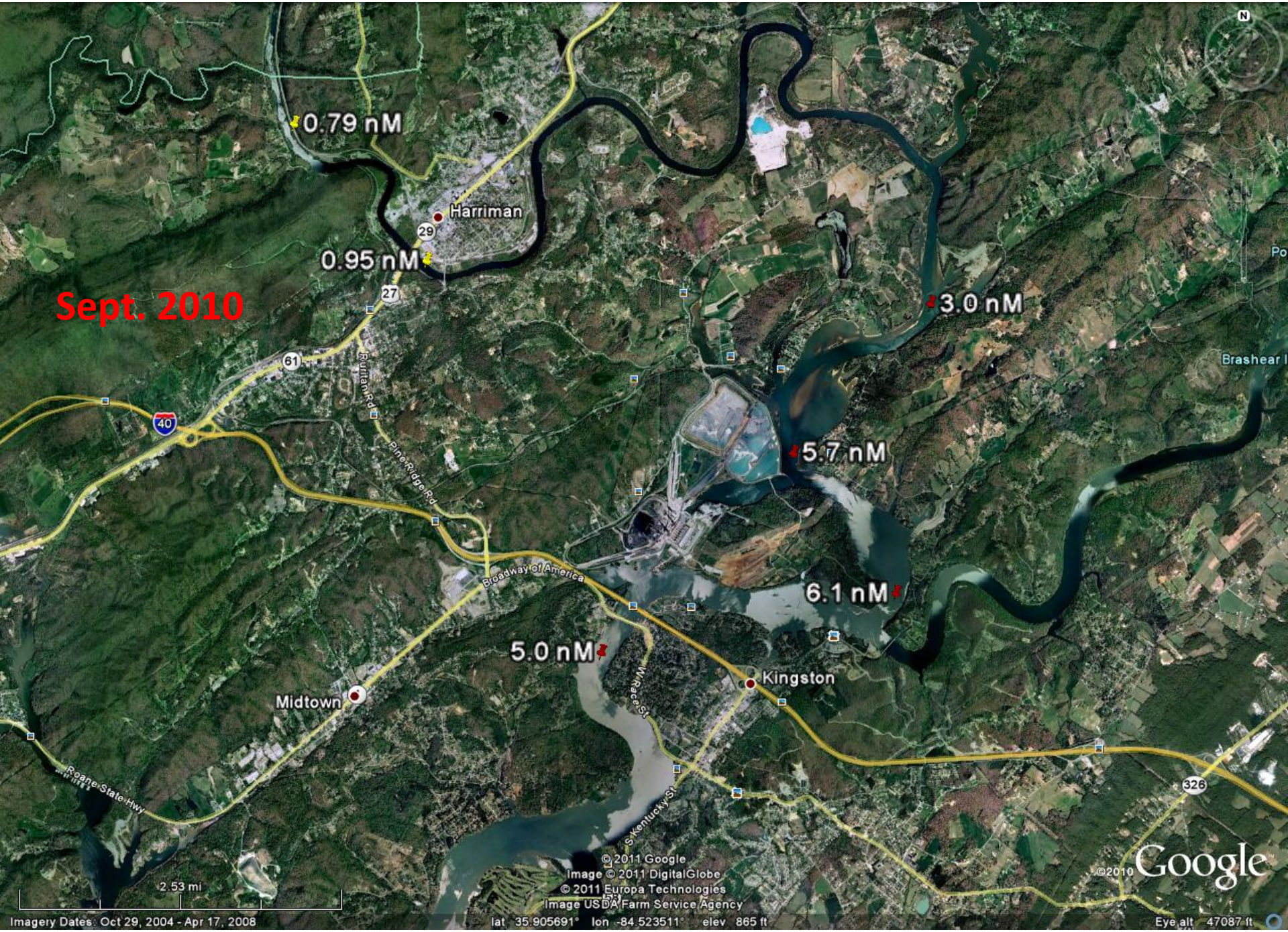

Sept. 2010
0.79 nM
Harriman
29
0.95 nM
27
61
40
Ruritan Rd
Pine Ridge Rd
3.0 nM
Brashear
5.7 nM
Broadway of America
6.1 nM
5.0 nM
Kingston
W Race St
Midtown
Roane State Hwy
S Kentucky St
326
2.53 mi
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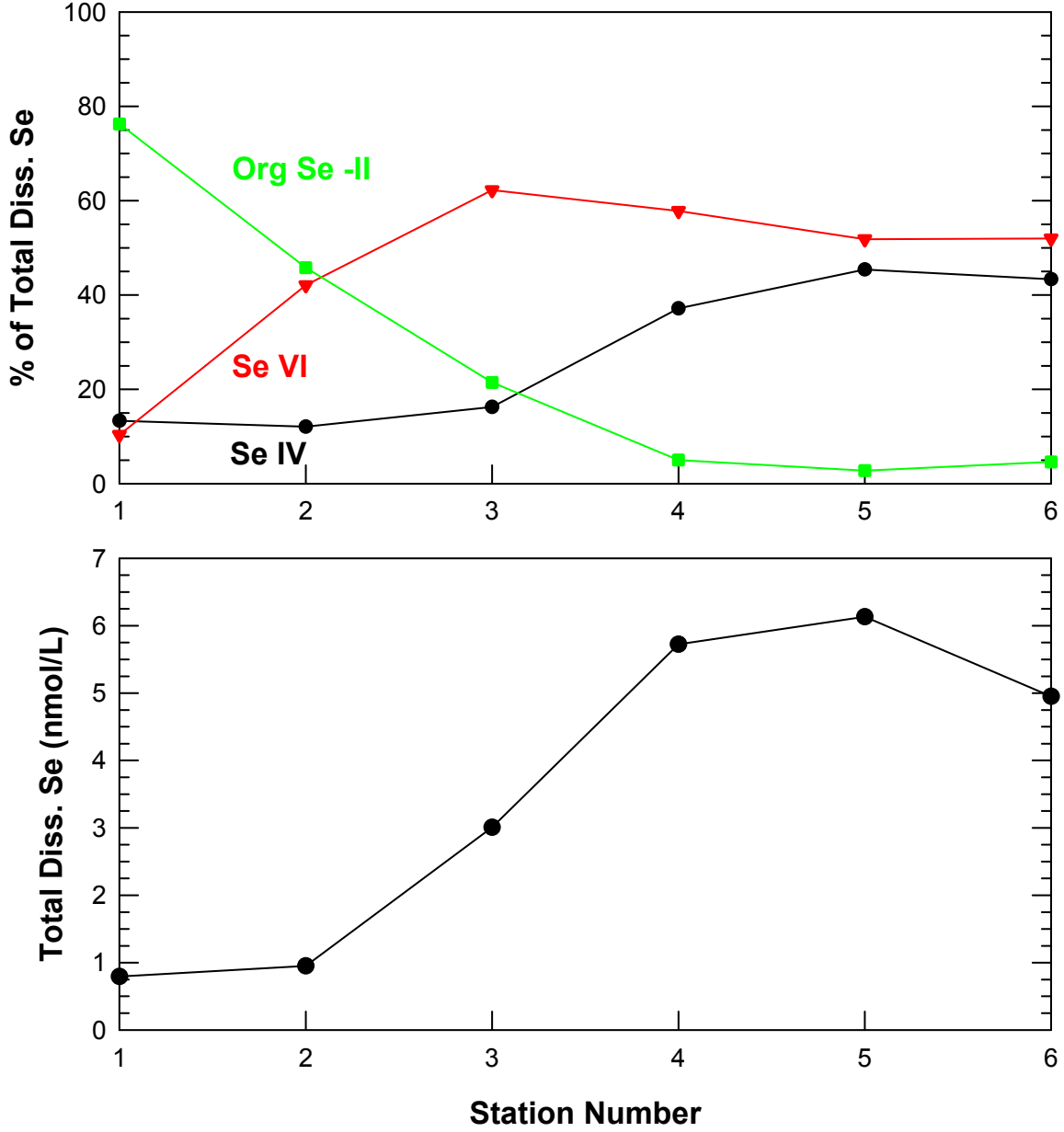
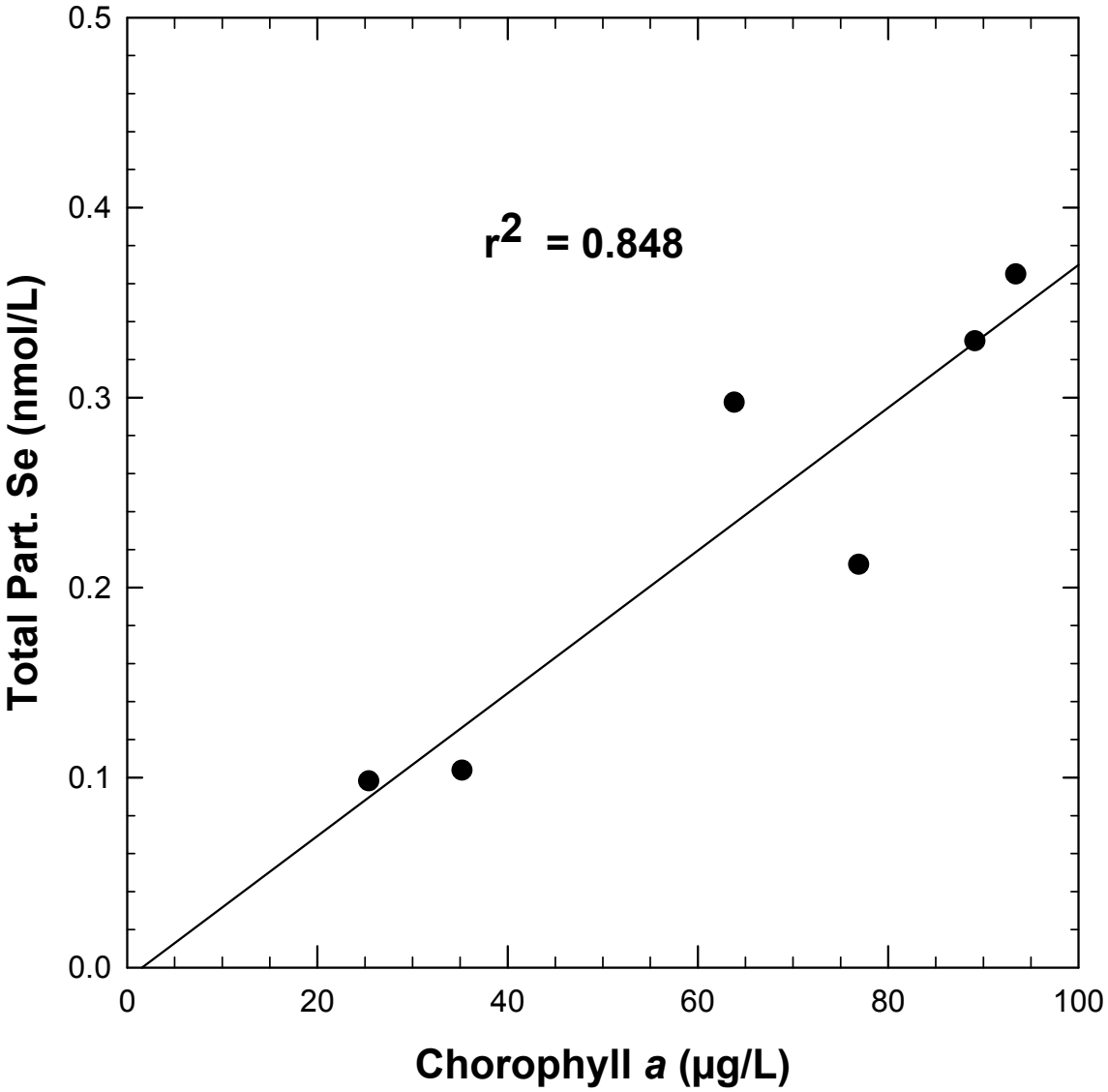
Image © 2011 DigitalGlobe
© 2011 Europa Technologies
Image USDA Farm Service Agency
©2010 Google
Imagery Dates: Oct 29, 2004 - Apr 17, 2008
lat 35.905691° lon -84.523511° elev 865 ft
Eye alt 47087 ft

September 2010 Dissolved Selenium Speciation



Sept. 2010 Suspended Particles: Total particulate selenium and Chlorophyll *a*



Apr. 2011
0.48 nM
Harriman
0.50 nM
0.61 nM
0.76 n
0.75 nM
Stn 7
3.43 nM
Kingston, TN
Kingston
Midtown
Poplar Creek Island (historica
Brashear Island
Harriman Hwy
Hannah Hwy
Rurlan Rd
Pine Ridge Rd
Roane State Hwy
S Kentucky St
Gallaher Rd
9/3/2008
2.41 mi
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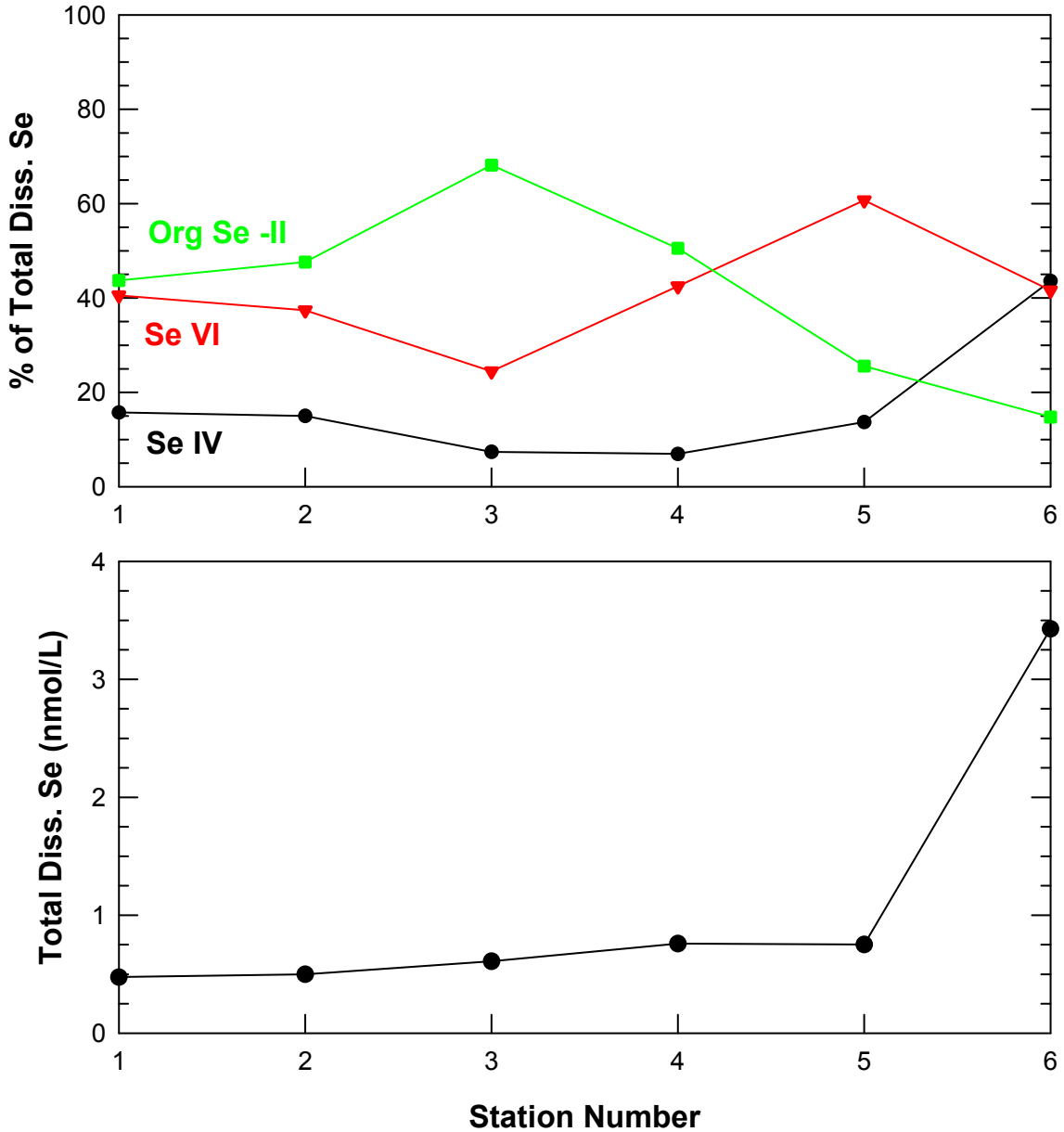
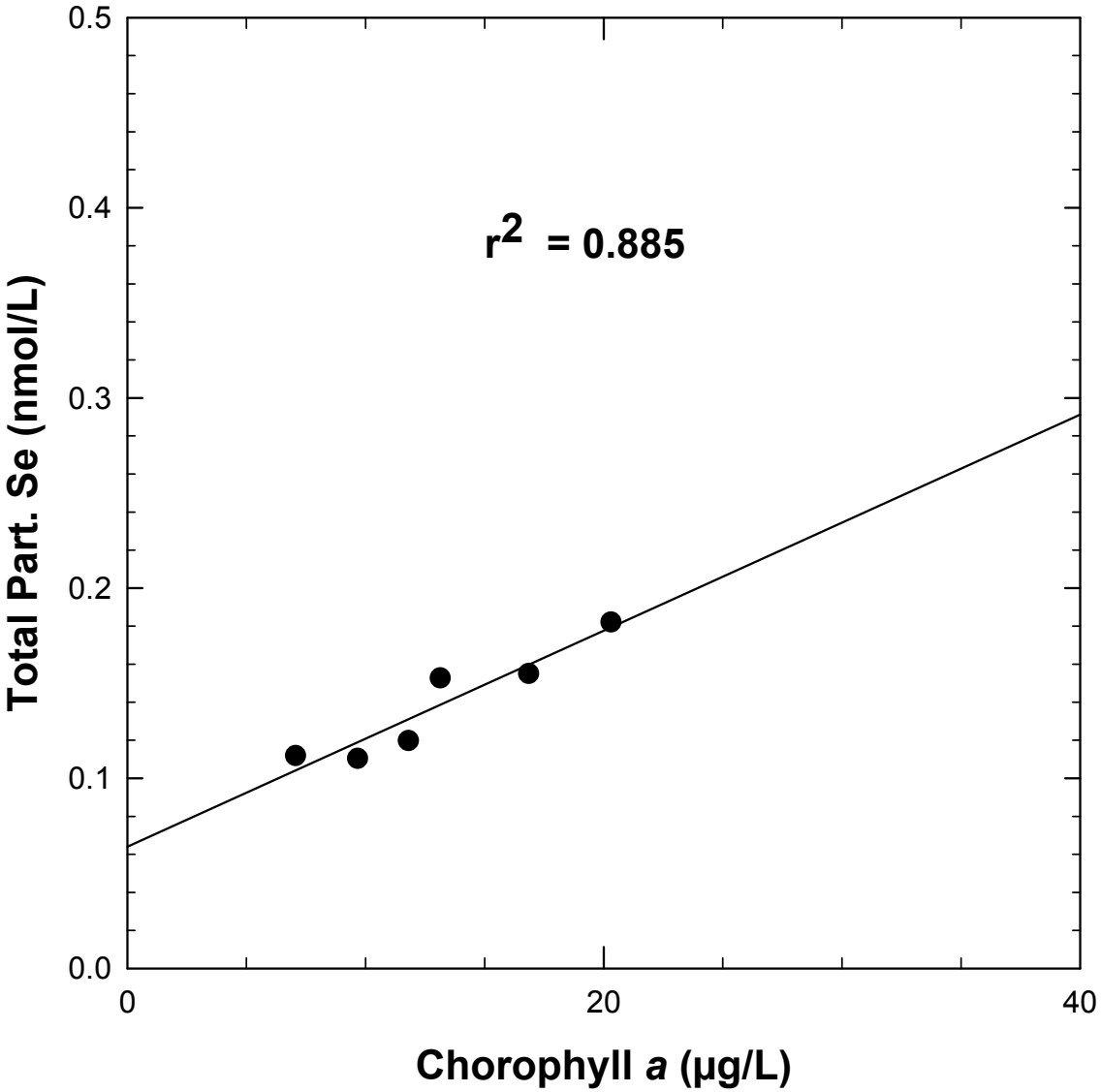
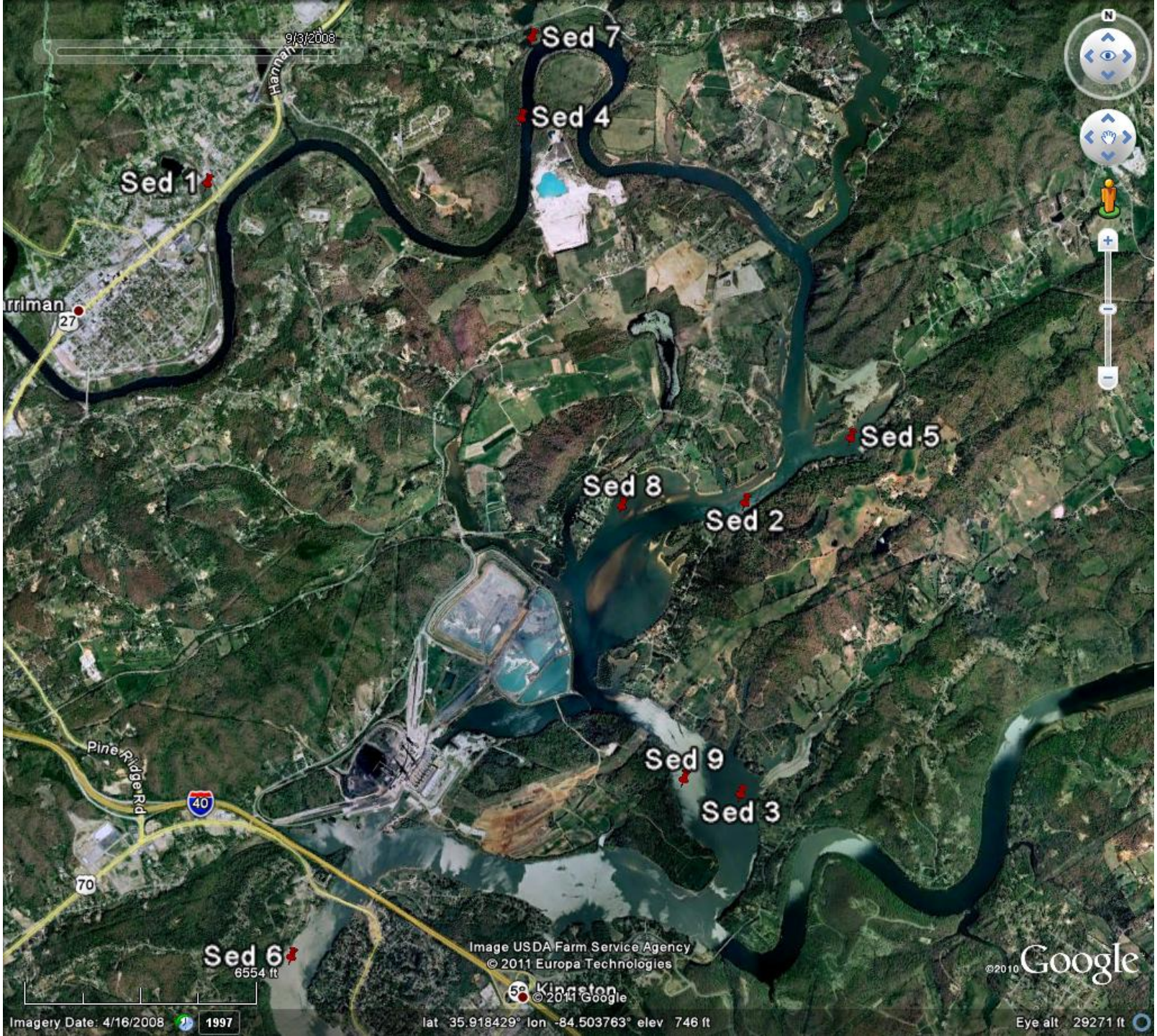
Image USDA Farm Service Agency
© 2011 Google
©2010 Google
Imagery Date: 4/16/2008
lat 35.910128° lon -84.513565° elev 757 ft
Eye alt 10.61 mi

April 2011 Dissolved Selenium Speciation



April 2011 Suspended Particles: Total particulate selenium and Chlorophyll *a*




9/3/2008
Sed 7
Sed 4
Sed 1
Hannah
rriman
27
Sed 5
Sed 8
Sed 2
Pine Ridge Rd
40
Sed 9
Sed 3
70
Sed 6
6554 ft
Image USDA Farm Service Agency
© 2011 Europa Technologies
Kingston
© 2011 Google
©2010 Google
Imagery Date: 4/16/2008
1997
lat 35.918429° lon -84.503763° elev 746 ft
Eye alt 29271 ft

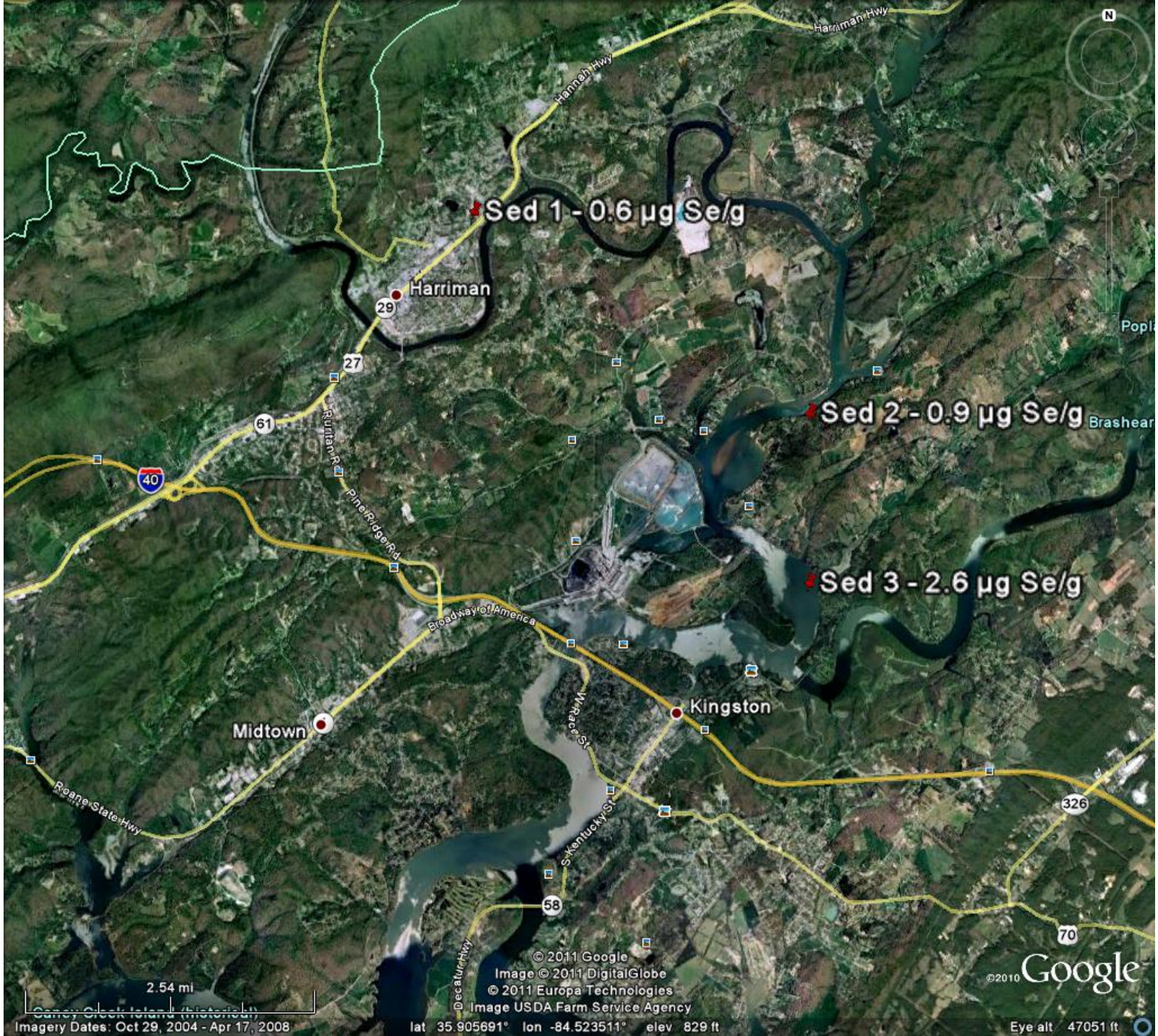

Sed 1 - 0.6 µg Se/g
Harriman
Sed 2 - 0.9 µg Se/g
Sed 3 - 2.6 µg Se/g
Kingston
Midtown
Harriman Hwy
Hannah Hwy
Rustan Rd
Pine Ridge Rd
Broadway of America
W Race St
S Kentucky St
Roane State Hwy
Decatur Hwy
29
27
61
40
326
58
70
2.54 mi
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Image © 2011 DigitalGlobe
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Image USDA Farm Service Agency
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Imagery Dates: Oct 29, 2004 - Apr 17, 2008
lat 35.905691° lon -84.523511° elev 829 ft
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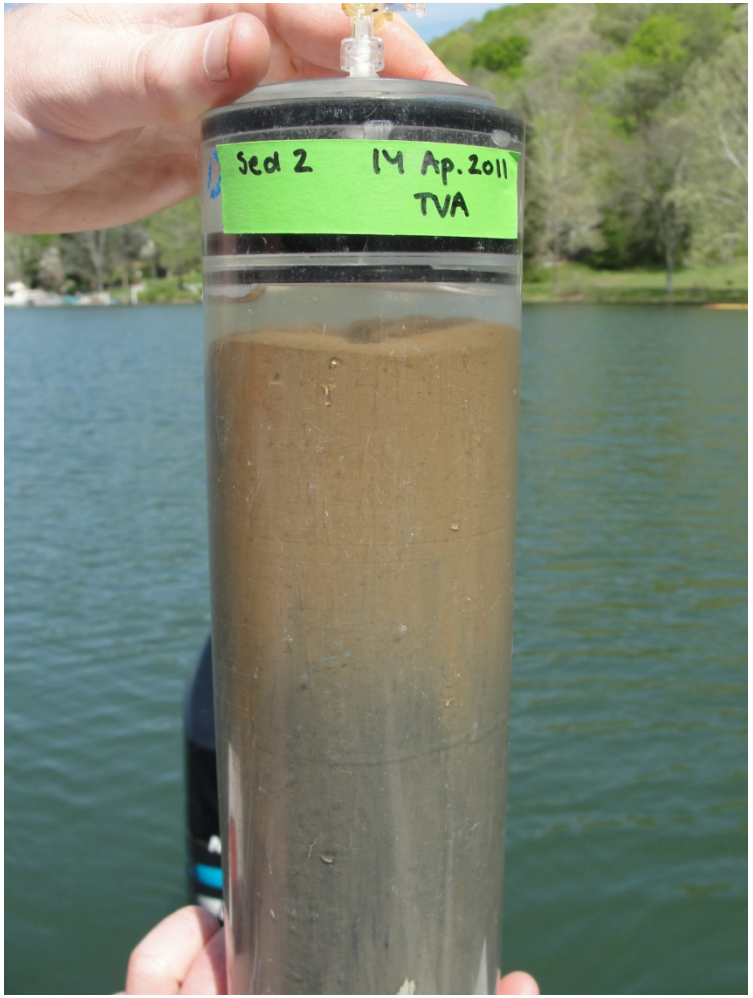
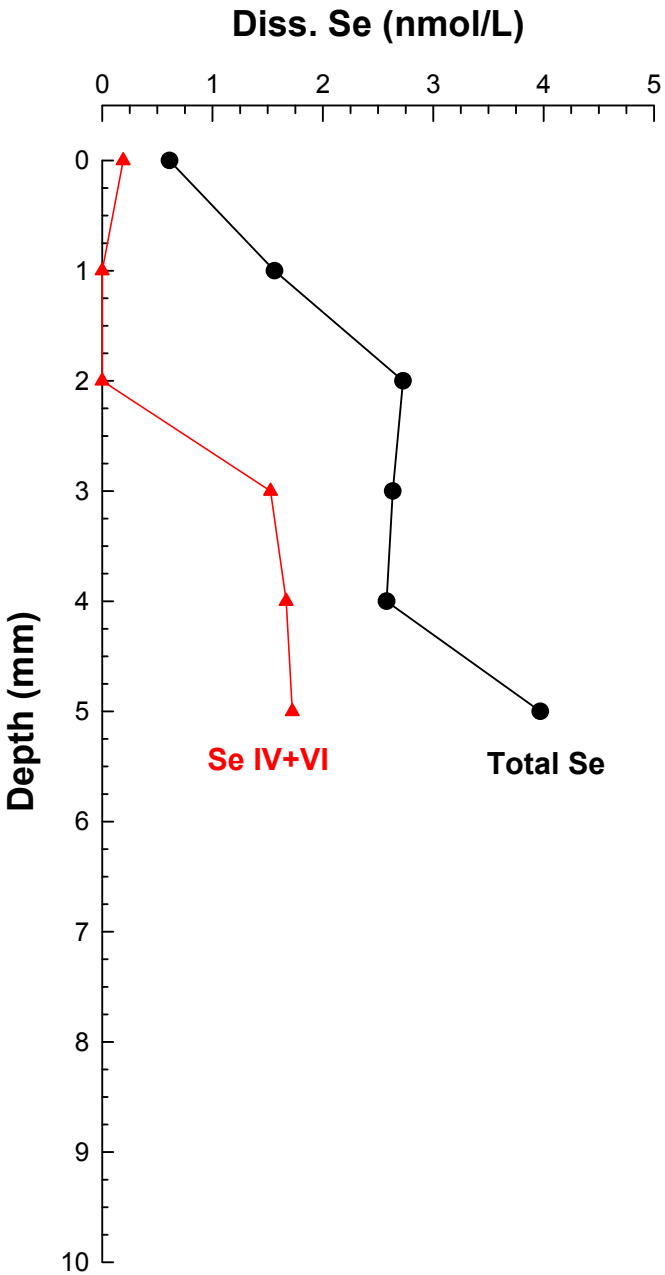
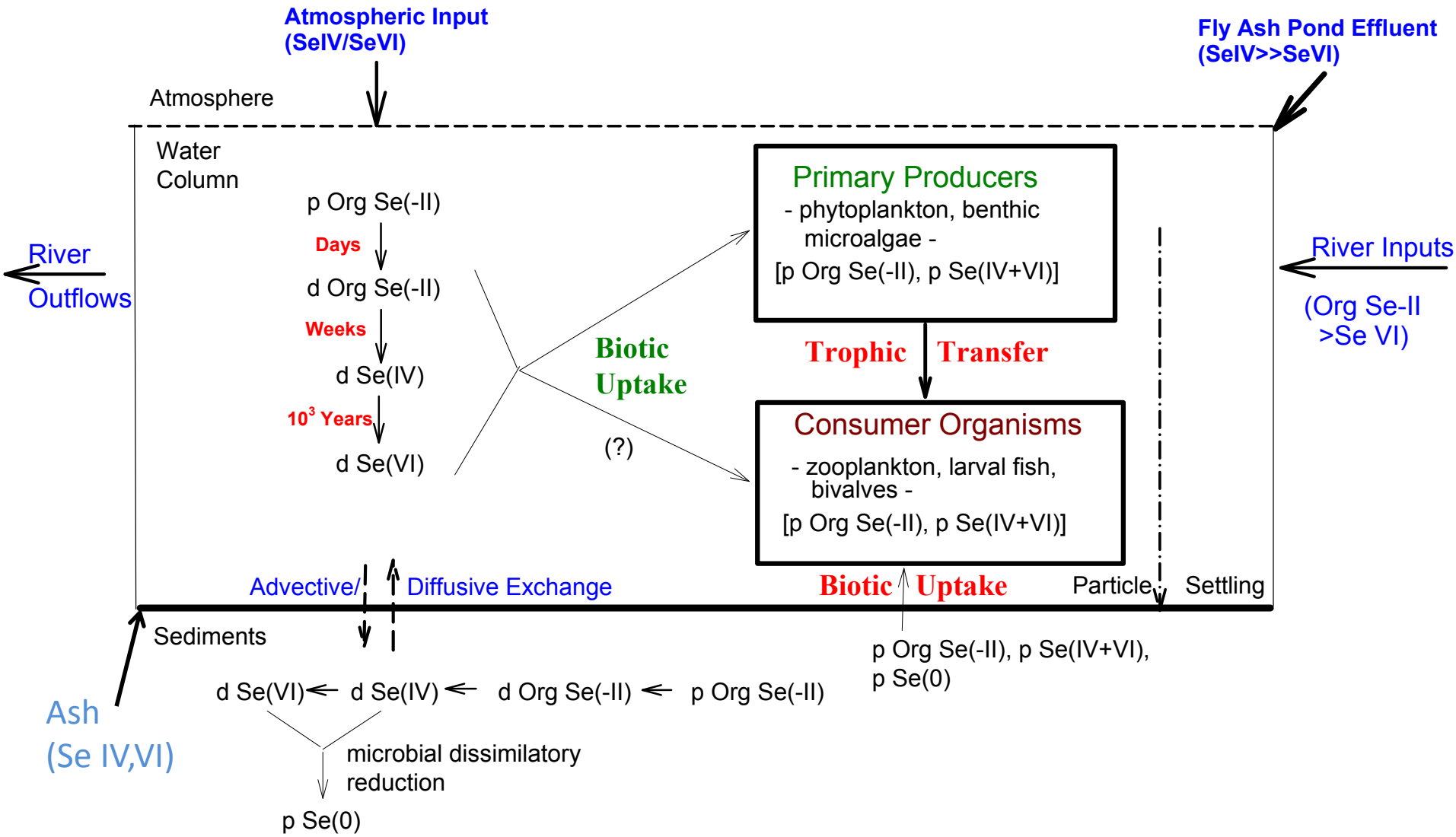


April 2011 Porewaters - Sed Stn. 5




Atmospheric Input
(SeIV/SeVI)
Fly Ash Pond Effluent
(SeIV>>SeVI)
Atmosphere
Water
Column
p Org Se(-II)
Days
d Org Se(-II)
Weeks
d Se(IV)
10³ Years
d Se(VI)
Biotic
Uptake
(?)
Primary Producers
- phytoplankton, benthic
microalgae -
[p Org Se(-II), p Se(IV+VI)]
Trophic
Transfer
Consumer Organisms
- zooplankton, larval fish,
bivalves -
[p Org Se(-II), p Se(IV+VI)]
River
Outflows
River Inputs
(Org Se-II
>Se VI)
Advective/
Diffusive Exchange
Biotic
Uptake
Particle
Settling
Sediments
p Org Se(-II), p Se(IV+VI),
p Se(0)
Ash
(Se IV,VI)
d Se(VI)
d Se(IV)
d Org Se(-II)
p Org Se(-II)
microbial dissimilatory
reduction
p Se(0)